arrange for some common system of observation in this branch. So with each of the sciences: conjoint action would solve many problems that are of the highest interest.

Then, again, there would be a great influence on the extension of science-teaching in the public schools, that would certainly come from the existence of such local societies. The greatest danger that now menaces natural science is, that the parrot system of teaching, so long applied to other branches of learning, will be taken in science-teaching. The presence of a little band of actual inquirers in any town will be the best possible assurance against this. Let the children have some share in the open-air actual study, and the evil of the book-system will surely be mended in part; for its imperfections will be seen.

It will often be possible to organize such a club in immediate connection with the schools of the town where it started. Experience in Europe shows that children readily and zealously engage in such inquiries, and need only a little direction in their work.

However we look at it, we see much to hope from the extension of the field-club system of science study.

THE NATIONAL RAILWAY EXPOSITION.

I.

THE exhibition of railway appliances now being held at Chicago is probably the most complete collection of all the varied apparatus used in every department of railroad working and construction that the world has ever seen; and the management are to be congratulated, that, while little has been omitted to make the show complete, still less has been included which is foreign to the subject of railroads. The exhibits range over a wide field, from uniform-coats to steel rails, railroad officers' desks to revolving snow-ploughs, and from an electric railroad in full working, and earning quite handsome traffic receipts, to George Stephenson's first locomotive, which is shown by an English railway company.

The main questions which are now awaiting solution in the railway world are well represented in the exposition. The cheap transport of heavy freight-trains over steep grades, the conveyance of perishable articles, such as meat and fruit, and the control of the *vis viva* or momentum of trains, are all questions which have to a certain extent been solved; and further developments of these solutions are shown. A locomotive of unprecedented size and power, fitted with a valve-gear of novel construction, which yields excellent results, is shown by the Southern Pacific railroad, and a large number of fine engines are shown by the Brooks and other locomotive works. The exhibition of refrigerator cars is very complete, and most of them appear to be of simple and efficient design. Continuous brakes, applicable to freight-trains, are exhibited; and as some of them appear worthy of careful examination, we shall refer to them later on.

While there can be no doubt, that as regards cheapness and rapidity of construction, general excellence of bridges, locomotives, and cars, the railways of this country are ahead of the rest of the world, the signalling arrangements here, with few exceptions, are rudimentary and inefficient, and render fast travelling a matter of considerable difficulty, if not danger. It is impossible to run a really fast express-train if the signals are ambiguous, and if every level crossing is made a compulsory stopping-place. The saving in time by fast trains can only be fully felt in a great country, where very long journeys are not only possible, but are frequently undertaken; but hitherto this fact has been little appreciated, and people have been content to travel at a slow speed, and put up with frequent stoppages, because the railways were new, the rails roughly laid, and many bridges unsafe at a high speed. But of late years these conditions have been materially changed. The wide-spread use of steel rails, the greater care bestowed on the road-bed, and the introduction of iron bridges of first-class workmanship, have rendered high speed perfectly safe and easy on most parts of good roads in the eastern and middle states; but it is rendered unsafe where switches are so arranged that they may be left open to an approaching train without any signal warning the engineer, or the signals are so formed that the difference to the eye between a clear or all-right signal and a danger or stop signal is slight in snowy weather or under certain atmospheric conditions which render the difference between colors imperceptible, though a difference in form may be perceived.

The exposition is, however, especially strong in signal apparatus; and there can be little doubt that the most important result of the exhibition will be the wide-spread adoption

of some of these safety appliances, rendered necessary by the increased number of trains, and the fact that the thicker and more numerous population now demands both safer and faster travelling. The real gain of time to a business-man, obtained by a difference of a few miles an hour in the speed of a long-journey train, is best illustrated by an actual case, — a man in New York who wishes to do a day's work in Chicago. He takes one of the fastest and best appointed trains he can find, — the Chicago limited. It leaves New York at nine A.M., and lands him at Chicago at eleven the next morning, having accomplished nine hundred and eleven miles in twenty-six hours fifty-five minutes, allowing for the difference in time between the two cities. This makes an average speed of 33.8 miles per hour, including all stoppages. But assume, what is surely not extravagant, that as high a speed can be attained on the Pennsylvania or any other first-class American road as on an English main line, and what shape does the problem assume? On one English road, the Great northern, the distance between Leeds and London (a hundred and eighty-six miles and three-quarters) is done in three hours forty-five minutes, including five stoppages; on another, the Great western, the hundred and twenty-nine miles and three-quarters between Birmingham and London is run in two hours forty-five minutes, including two stoppages; and as neither of these routes is particularly level or straight, and both pass through numerous junctions with a perfect maze of switches and frogs, they give a fair idea of what is possible in speed on the railroads of this country. These figures give, respectively, speeds of 49.8 and 47.2 miles per hour. Taking as a fair average forty-eight miles an hour, including stoppages, the journey from New York to Chicago should be done in eighteen hours fifty-nine minutes, or, say, nineteen hours, — a saving of seven hours fifty-five minutes on the present time; so that, if the train were arranged to leave at fifty-five minutes past four in the afternoon instead of nine o'clock in the forenoon, the whole of this time would be saved in the busy part of the day, effectually adding a day to our imaginary traveller's business and dollar-making life.

It may be thought that such a deduction is unfair, as the English style of car is so much lighter than the American; but, as a matter of fact, the average English express-train is considerably heavier than the Chicago limited, and conveys about three times the number of passengers; and, as trucks and oil-lubricated axle-boxes are not yet universal there, the tractive resistance per ton is probably higher. It certainly, therefore, seems not only possible, but feasible, to attain these high speeds in this country, where, owing to the long distances to be travelled, they are more valuable than in England; and the great step towards attaining that end is the adoption of proper and efficient signalling arrangements. All the other steps are achieved: the American passenger locomotive of the present day is perfectly competent to drag a heavy train at a speed of over sixty miles an hour; the cars, as now constructed, can travel safely and smoothly at that speed; and the steel rail, the well-ballasted tie and perfect workmanship of the modern iron bridge, can well support the thundering concussion of an express-train at full speed. But this speed can only be maintained for a few miles at a time if the engineer who guides this train be doubtful whether that dimly-seen signal imply safety or danger, or if the laws of the state bring him to a full stand where his road is crossed by a small corporation with a high-sounding title, which owns one locomotive with a split tube sheet and two cars down a ditch.

To run a fast train, a clear, uninterrupted road is absolutely necessary; and the reason is not far to seek. To move a body from a state of rest to a velocity of sixty miles per hour or eighty-eight feet per second, an amount of work must be performed equivalent to lifting that body a hundred and twenty-one feet. Now, it is apparent to the simplest capacity that it requires a pretty powerful engine to overcome the resistance of a train running at sixty miles per hour without every few miles putting on brakes to destroy this velocity, and then to lift it a hundred and twenty-one feet again to attain speed; the resistance of the air, and the friction of bearings on journals and of flanges against rails, going on all the time. As a matter of fact, showing what severe work this is on an engine, the Zulu express on the Great western railway of England, which is the fastest train in the world, has been repeatedly carefully timed; and it is found, that, though running over an almost absolutely level and straight road, it takes a distance of twenty-six to twenty-eight miles to attain its full speed, about fifty-eight miles and a half an hour.

The adoption of a safe and thorough system of signals, efficiently warning the engineer of a train of any danger in his path, whether from a misplaced switch, an open draw, or a

freight-train ahead, may be regarded as of great importance to the American railroad system, in a manner crowning the edifice, and enabling roads to be operated with greater speed, safety, and regularity.

(*To be continued.*)

THE INFLUENCE OF GRAVITATION, MOISTURE, AND LIGHT UPON THE DIRECTION OF GROWTH IN THE ROOT AND STEM OF PLANTS.

MEMBERS of my present botany class have performed some experiments this spring, bearing upon the above caption, which, although not developing any thing new in the interest of the extension of experimental methods in the lower schools, it seems to me may be found worthy of a record in the columns of SCIENCE.

Seven balls of moss, about four inches in diameter, were prepared, in the centre of which were planted from fifty to a hundred grains of oats, barley, or corn; in some cases a mixture of two of these grains.

No. 1 was suspended in free air, lighted on all sides. No. 2 was placed on a glass tumbler, in the bottom of which some water was kept, but not enough to rise within two inches of the lowest part of the ball. No. 3 was fitted into the mouth of an inverted bell-glass in such a manner that one half of the ball was within the jar and one half without it. No. 4 was placed one half within and one half without a bell-glass placed in a horizontal attitude. No. 5 was in a tight tin can, the ball fitting it like a stopper, so as to exclude the light and to prevent a circulation of air. One-half of the ball protruded from the can, and the can was inverted. No. 6 was placed in a can similar to that of no. 5; but this was placed in a horizontal attitude, as in no. 4. No. 7 was mounted upon a spindle running through its centre. The spindle was attached to the stem of the minute-hand of an eight-day clock in such a manner that the axis of the spindle was a continuation of the axis bearing the minute-hand of the clock. The spindle was a piece of one-eighth inch brass wire having a strip of tin soldered to one end of it. The tin was perforated with a square hole, exactly fitting the shaft of the minute-hand of the clock. The other end of the wire was filed down to form a small journal, which worked in a hole bored in a lump of solder secured to the end of a wire which acted as a support to the distant end of the spindle. This supporting wire was first bent double, forming a narrow V, and the solder, which served as a box for the journal, dropped in the vertex. The two arms of the V were then bent upon themselves in the same direction so as to form a right angle with the plane of the V. Two holes were bored in the frame of the clock above the dial, but close to it, and the arms of the bent V inserted. The minute-hand was then removed from the clock, and also the washer behind it. The tin shoulder of the spindle was then placed upon the shaft, and the minute-hand replaced; the shoulder serving in the place of the washer, which had not been replaced. It was only necessary to shorten the pendulum a little to enable the clock to record time with its usual regularity.

The results observed after germination were as follows: —

In no. 1 the stems all came out in a clump at the top of the ball, and the roots in a cluster from the under side. The roots, however, after protruding from half an inch to an inch, curved upon themselves, and re-entered the ball, or else withered. In no. 2 the stems all came out at the top, and the roots at the bottom; but the roots in this case continued straight downward into the water, no one of them turning back into the ball. In no. 3 the plants deported themselves in all respects as those did in no. 1, except that the growth was very much more rapid. In no. 4 all of the stems except two came out of the ball into free air: two grew horizontally into the bell-jar. A large cluster of the roots came out of the ball and entered the jar, and continued to grow horizontally, only depending so much as was necessary by their own weight. Others of the roots emerged from the lower side of the outer half of the ball, but soon entered it again. In no. 5 all of the stems came up in the dark, damp atmosphere; and the roots emerged from the lower side of the ball, but re-entered it again, or else perished. Many of the stems (oats in this case) threw out a pair of opposite bodies, apparently secondary rootlets, which grew horizontally, in all cases observed, to a length of about one inch. The color of the stems in this case was a pale yellow. In no. 6 all of the stems came from the ball upward into the light, and very many of the roots protruded horizontally into the can, some of them leaving the ball above its centre. A corn-root extended itself horizontally four inches beyond the surface of the ball, and in that distance was only depressed one-half of an inch. On the corn-roots back of the sensitive tips, the delicate root-hairs were so numerous and long as to give it a resemblance to the hair-brush for